Vol. XIV. *January, 1908.* *No. 2*

BIOLOGICAL BULLETIN

GILL DEVELOPMENT IN MYTILUS.[1]

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In the present paper no attempt is made to give an exhaustive treatment of the subject; the intention is rather to summarize briefly the work that has been done upon the development of the lamellibranch gill, and to describe somewhat fully certain phenomena in the development of the gill of *Mytilus* which seem thus far to have escaped notice. A few incidental observations on gill development in other lamellibranch genera are added.

Terminology.

The term ctenidium is used in the following pages to designate the entire respiratory apparatus of one side of the body. The halves of each ctenidium are called, in accordance with common though questionable usage, the gills, outer and inner respectively according to position adjacent to the mantle or to the body mass. Each gill, again, is composed of two lamellæ, called respectively the direct (or descending) and reflexed (or ascending). The same terms are employed in describing the limbs of the filaments composing the lamellæ. It will be noticed that the reflexed lamellæ (and filament limbs) of the outer and inner gills are turned in opposite directions — that of the inner gill toward the body, that of the outer gill toward the mantle. The *Mytilus* gill is of a very simple filibranchiate type in which the interfilamentary connections (between neighboring filament limbs of the same lamella)

[1] The studies upon which the present paper is based were carried on largely in the Marine Biological Laboratory, Woods Hole, Mass., and the Harpswell Laboratory, South Harpswell, Me. I am happy at this opportunity to express my appreciation of the courtesies and assistance extended by the directors of these institutions, Professors C. O. Whitman and J. S. Kingsley, and by their associates.

are represented solely by tufts of interlocking cilia, the ciliated disks (Fig. 7, *B*, *a*). The interlamellar connections are also very simple, consisting of hollow, cylindrical bridges, several of which extend between the two limbs of each adult filament (Fig. 7, *B*, *b*).

Résumé of Previous Investigations.

The classic on the development of the gill in the Lamellibranchiata is the paper by Lucaze-Duthiers ('56) entitled "Mémoire sur le développement des branchies des mollusques acéphales lamellibranches." A preliminary report ('54) preceded it. The first anlage of the ctenidium is described as a row of papillæ arising inside the mantle, along the line of juncture of mantle and body. These lengthen, bend back upon themselves, and become the filaments of the inner gill. Later a second series of similar papillæ form just outside the first, and develop similarly into the outer gill. Each gill thus passes through a stage in which it is composed of a row of unbent filaments hanging down in the mantle cavity.

The work of Lucaze-Duthiers was preceded by two interesting papers by Lovén ('49), in which young bivalves of several species are described and clearly figured with the ctenidium consisting of from three to ten free filaments belonging to the inner gill. The material was obtained from the plankton; and the identification (*Mya*, *Tellina*, *Mytilus*, *Mactra*, and *Nucula* are hesitatingly named) was recognized as very questionable by Lovén himself. Moreover, little account of the development is given.

Since the time of Lovén and Lacaze-Duthiers the investigation of gill development has been extended to a considerable number of widely separated genera of lamellibranchs.

Early stages of *Cyclas* were studied by O. Schmidt ('54); and his work on this genus has been extended by Leydig ('55), Stepanoff ('65), and Ziegler ('85), while Lankester ('75) gives brief notes on the closely allied genus *Pisidium*.

Unio and *Anodonta* have been described by Braun ('78), Schierholz ('78, '89), and F. Schmidt ('85).

The earliest stages of the gill of *Teredo* have been described briefly, and not very clearly, by Hatschek ('80). Sigerfoos ('96) has confirmed the observations of Hatschek and extended them to much later stages.

Ostrea has been briefly considered by Ryder ('84) and Stafford ('05).

Mytilus has been equally briefly described by Wilson ('87).

Dreissensia is known through the work of Korschelt ('91), Weltner ('91), and Meisenheimer ('01).

And, finally, the gill development of the peculiar and primitive Nuculidæ, *Nucula* and *Yoldia*, has been very carefully followed by Drew ('99, '01).

The accounts are for the most part brief, in some cases only incidental; and there are various points of divergence in detail. One such divergence appears at first to be fundamental. While Lacaze-Duthiers describes the first anlage of the gills as a series of isolated papillæ, the majority of the authors cited trace the ctenidium back to a longitudinal fold or ridge, which is secondarily constricted transversely and divided into the papillæ. Thus emphatically, among later writers, Ziegler for *Cyclas*, Schierholz for *Unio*, and Sigerfoos for *Teredo*. Drew describes a primary ridge and secondary papillæ in the Nuculidæ, but considers the change to be "due to unequal growth more than to constriction"; his figures, however, give evidence of considerable constriction.

On the other hand, Wilson confirms the early view of Lacaze-Duthiers for *Mytilus;* and my own observations are entirely in accord with this view. Concerning *Dreissensia* Korschelt ('91, p. 144) expresses himself thus cautiously: "Ob sie (the gills) in Form einer Falte angelegt werden, die sich schon sehr bald einkerbt und so jene vermeintlichen Papillen entstehen lässt, oder ob sie als wirklichen Papillen hervorsprossen, ist schwer zu entscheiden."

In the adult of all forms a continuous and undivided gill axis may be recognized, comparable with this embryonic fold or ridge. Upon this are carried the filaments, comparable with the embryonic papillæ. The whole divergence, then, reduces itself to a question of the relative time of development, and is one of minor importance. Much more significant is the general uniformity of development, and the recognition, by all the authors cited and in all the genera studied, of a stage in which each ctenidium is represented by a series of simple papillæ belonging to the inner gill; and of a later stage in which the outer gill is formed of a parallel series of corresponding papillæ.

Concerning the process of elongation and flexure by which the embryonic papillæ are metamorphosed into the definitive filaments of the adult gill in all forms except the very primitive Protobranchia the authors are again in the fullest agreement, so far as their attention has been turned to this later development; and this plan of development has been generally accepted as characteristic of the whole class.

Stages of Gill Development in Mytilus.

The following tabulation gives the size of the animal and the number of filaments present in the gills at certain of the more important stages in gill development. The figures can be taken only as approximate, as there is considerable individual variation; but they probably represent fairly accurate averages as they are selected from a much larger tabulation.

Stage.	Size.	Number of Filaments.	
		Inner Gill.	Outer Gill.
Earliest stage in which gills were observed.	0.30 mm.	3	0
Flexure of filaments of inner gill.	0.75 mm.	12	0
First appearance of outer gill.	1.40 mm.	20	(?)[1]
Flexure of filaments of outer gill.	1.60 mm.	25	15

Order of Succession of Gill Filaments In Mytilus.

Lacaze-Duthiers describes the order of the development of the filaments of the inner gill as from front to back, the most anterior being the first to develop; in the outer gill the development is described as extending in both directions, so that the first developed filaments would come to lie in the middle of the gill, with late developed filaments at both ends. My observations are in accord with those of Lacaze-Duthiers as regards the inner gill; but, in the case of the outer gill, amendment is required.

In very early stages, in which the filaments of the outer gill are mere papillæ, the longest papilla is not the most anterior, but is even posterior to the middle of the series. In one specimen with ten such papillæ, the seventh from the front is the

[1] Theoretically but a single filament should be present. No stage has been actually observed with less than three or four. Apparently several filaments appear almost simultaneously.

longest, the most developed, and, apparently, the oldest. Lacaze-Duthiers figures an almost exactly similar stage ('56, Fig. 6), as well as one a little older ('56, Fig. 7) in which the ninth of fifteen filaments is the longest. This suggests strongly a development of the gill in both directions in the early stages.

On the other hand, a comparison of these early stages with others much older shows that the position of the anterior end of the outer gill is somewhat definitely located relatively to the inner gill. There seems to be some individual variation; but the extension of the inner gill in front of the outer is measured in all cases observed by about ten filaments. Owing to the non-parallelism of the filaments of the two gills, it is very difficult to interpret figures that have not been drawn with reference to this particular point; but a study of Lacaze-Duthiers's plate seems to show ten such filaments in an earlier stage ('56, Fig. 6) and eleven in a later ('56, Fig. 7). As the inner gill is growing only at the posterior end, and as the filaments of the two gills are arranged somewhat definitely in corresponding pairs, this indicates almost certainly that the addition of filaments at the anterior end of the outer gill is confined to very early stages, if present at all. As regards these early stages my observations are very inconclusive.

In this connection it is also interesting to note that in a comparatively early stage, when the animal is only about 1.60 mm. in length and the outer gill is composed of only about sixteen filaments, the anterior filament of this gill is already strongly differentiated from its neighbors in both size and shape. It is decidedly thicker and longer, and is furnished with a very peculiarly enlarged and twisted termination. In both total preparations and sections it is very distinct from the other filaments and very easily identified. From this time on the development of the outer gill is clearly from front to back only, and the two gills develop *pari passu*.

Mode of Formation of Later Filaments in Mytilus.

The early filaments of the *Mytilus* gill follow the mode of development so beautifully worked out by Lacaze-Duthiers, and outlined briefly above; the later filaments follow a very different

mode. The change may be noticed in specimens but a little older than the latest stage figured by Lacaze-Duthiers. The ctenidium has grown beyond the rather small body mass and the posterior adductor, and extends free into the mantle chamber (Fig 1). The posterior part of the ctenidium is free from the mantle except for a light attachment due to the interlocking of

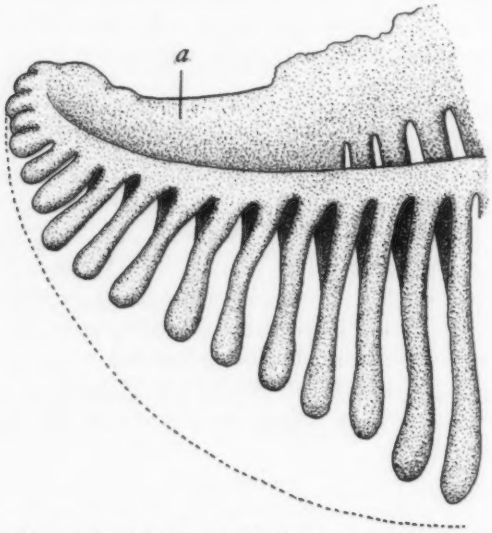

FIG. 1. Posterior tip of ctenidium of *Mytilus* of 2.5 mm. length, viewed from inner side. Outer gill omitted except for outline represented by dotted line. Magnification 170.

cilia. This suggests the connection of neighboring gill filaments (interfilamentary connections); but here there is merely diffuse ciliation and no specialized ciliated disks.

At the posterior end the gill axis (Fig. 1, *a*) is slightly curved upward; and around this curved end the developing filaments are closely crowded and assume a radial arrangement. The anterior filaments are attached to the ventral side of the axis and hang down ventrally; toward the end the position becomes more and more oblique, and then horizontal; while the youngest filament anlagen actually project upward from the dorsal side of the axis. Here all stages in filament development may be observed, ar-

ranged accurately in serial order. In Fig. 4 are seen isolated portions from the posterior end of the ctenidium. The specimens figured are selected from a large number of dissections, and are taken from several individuals of slighty varying size. Hence the discrepancy in the size of the figures, as all are equally magnified. All the stages figured have been observed again and again.

From the figures it is clearly seen that we are dealing with something very different from the comparatively long and slender

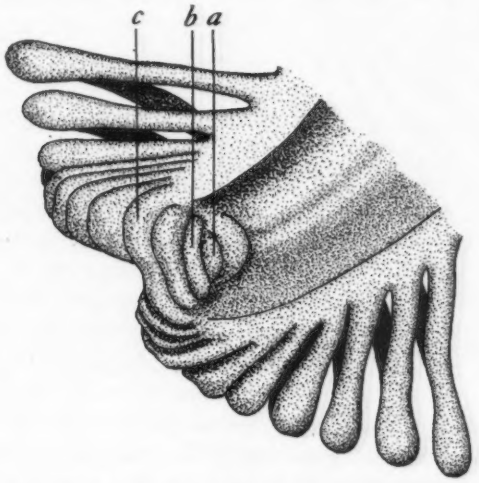

FIG. 2. Posterior tip of ctenidium of *Mytilus* of 3.0 mm. length, spread out, and viewed from dorsal side. Inner gill below and to right. Magnification 170.

rod-like papillæ observed in younger specimens. The youngest anlagen are rather transverse folds or ridges on the dorsal and posterior sides of the gill axis. At first these ridges are comparatively short and of uniformly convex contour (Figs. 4, *A*; 2, *a*; 3, *a*). Then the ridge elongates and becomes flat topped (Figs. 2, *b*; 3, *b*); and soon a process of differential growth or constriction leads to a notching of the ridge near its middle (Figs. 2, *c*; 3, *c*; 4, *B*). This notch divides the originally simple anlage into two slightly unequal parts, the larger belonging to the outer gill and the smaller to the inner. These two parts grow rapidly

(Figs. 4, *C*; 4, *D*), and may be followed readily into the characteristic filaments of their respective gills (Figs. 2 and 3).

In this connection it should be strongly emphasized that the filament anlagen here described are by no means the equivalent of the papillæ described by Lacaze-Duthiers, although their appearance in such a stage as that figured in Fig. 4, *D*, is strikingly similar. The undivided transverse fold (Fig. 4, *A*) contains potentially an entire filament of each gill; and each of its subdivisions (Fig. 4, *D*) is the equivalent of the two limbs of a filament placed side by side. On the other hand, the earlier type of anlage must be considered as the equivalent of only one limb of the definitive filament, or perhaps better, of the two placed end to end. In the earlier type the reflexed limb of the filament originates through a bending of the anlage; in the later type there is no bending, but rather a longitudinal splitting. The exact details of this splitting and the formation of the cavity within the gill, shown in Fig. 4, *E*, have not been worked out; but a study of a series of specimens such as those represented in Fig. 4 makes it clear that the process consists essentially in a thinning and ultimate perforation of the plate-like anlage of Fig. 4, *D*.

FIG. 3. Posterior tip of ctenidium of *Mytilus* of 4.5 mm. length, viewed from inner side. Magnification 170.

Corroborative evidence as to the nature of these later filament anlagen and their distinction from the earlier and more anterior ones is found in the character of the ciliation. A comparison of Figs. 4 and 5 is instructive in this connection. Fig. 5 is drawn from a section; but the filaments of the gills have been slightly reconstructed from neighboring sections, so that they are represented in their entirety. This represents an earlier filament of the outer gill (Fig. 5, *b*), with its characteristic rod-like form. Details of the ciliation have been omitted except for the some-

what diagrammatic representation of the highly specialized ciliated epithelium characteristic of the outer side of the filament, *i. e.*, the side turned away from the cavity of the gill. Thus in the inner gill (Fig. 5, *a*) the outside of each limb of the bent filament shows this characteristic ciliation; the papilla, or unbent filament, of the outer gill is ciliated on only one side, and that the side corresponding to the outside of the direct limb. In the later filaments (Fig. 4) the conditions are very different. In the

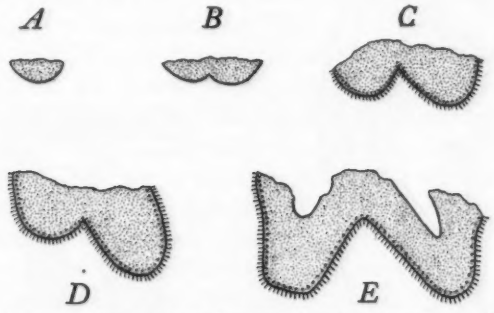

FIG. 4. Isolated filament anlagen from posterior tip of ctenidium of *Mytilus*. In all cases, anlage of outer gill at right. *A* and *B* from specimen of 2.25 mm. length; *C* from one of 2.00 mm.; *D* from one of 2.30 mm.; *E* from another specimen of 2.25 mm. Magnification 140.

two youngest stages represented (Figs. 4, *A*; 4, *B*) the tissue is distinctly embryonic with no differentiation; but in the three older stages (Figs. 4, *C*; 4, *D*; 4, *E*) the ciliated epithelium is clearly distinguishable, and is located on both sides of the anlage, showing the equivalence of the latter to both limbs of the flexed filament.

Another difference between early and late filament formation is found in the relations of the upper end of the reflexed filament limb. In the earlier filaments, the reflexed limb, developed at the free end of the direct limb, is primarily free. In *Mytilus* it retains this freedom;[1] but in many lamellibranchs the upper ends of reflexed filament limbs are secondarily fused with the

[1] Even in *Mytilus* there is a fusion of the upper ends of the reflexed filament limbs with one another to form a somewhat definite border to the reflexed lamella of the gill.

mantle (outer gill) or body (inner gill). In the later type of development the upper end of the reflexed limb is primarily united with the gill axis (Fig. 4, *D*), and only secondarily attains its freedom. The details of the process have not been studied. In the specimen represented in Fig. 4, *E*, this separation had not taken place, but the reflexed limbs were torn loose in the dissection as indicated by the rough edges.

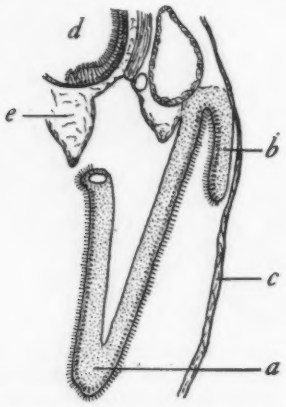

FIG. 5. Section through ctenidium of *Mytilus* of 1.6 mm. length. Section passes through posterior end of reduced foot. *a*, filament of inner gill; *b*, filament of outer gill; *c*, mantle; *d*, intestine; *e*, foot. Magnification 140.

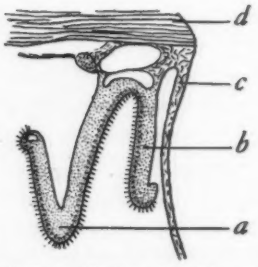

FIG. 6. Section through ctenidium of *Mytilus* of 1.6 mm. length. Section passes through middle of posterior adductor. *a*, filament of inner gill; *b*, filament of outer gill; *c*, mantle; *d*, posterior adductor. Magnification 140.

At first sight the two modes of filament formation seem fundamentally distinct; but the change from one to the other is bridged by all intermediate gradations. A comparison of Figs. 4, 5, and 6 gives some suggestion of the transition in the case of the inner gill; and the process is identical for the outer gill.

Figs. 5 and 6 are taken from the same animal, Fig. 6 being more posterior, thus showing a later filament in a younger stage of development. But it will be found by measurement that the ratio of the length of the reflexed limb to the direct limb of the filament of the inner gill is almost the same in the two cases, thus showing a precocious flexure of the posterior filament. A

further advance in this precocity leads to the condition found in a still later filament (Fig. 4), in which the flexure may be considered as having already occurred at the time when the filament is first budded forth.

Thus it is possible to conceive the later method of development as derived from the earlier; but it is equally possible, so far as mere geometrical relations are concerned, to reverse the series and consider the later mode as really primitive, the earlier mode as a specialization. It may be that the feeding requirements of the young animal are such as to require an adaptive modification in the direction of a speedy lengthening of the gill filaments; but it is likewise possible that the later mode of development is an adaptation to some factor or combination of factors in the life of the older animals. The startling similarity of the anlage of the later filaments to the gill in young specimens of the very primitive *Nucula*, as figured by Drew ('01, Fig. 46) make it very tempting to interpret the later type as primitive; but the structures are in such undeveloped condition that such comparisons are hazardous. The safe course is a suspension of judgment.

Filament Development in Other Lamellibranchs.

In connection with the above observations on *Mytilus*, the gill development in various other forms has been hastily studied for comparison. *Mya* is the only genus in which very young specimens have been observed. Here the early development seems to agree essentially with Lacaze-Duthier's description of *Mytilus*. Later stages have been studied in *Mya*, *Anomia*, *Modiola* and *Arca*. In all these genera the development of the later filaments follows the scheme here set forth for *Mytilus*. It is highly probable that this modification of development is characteristic of the later filaments in the Lamellibranchiata in general.

Development of Interlamellar Connections in Mytilus.

The contrast of the interlamellar connections in the closely related genera *Mytilus* and *Modiola* has been emphasized in a former paper ('98). In *Mytilus* these connections (Fig. 7, *B*, *b*) are irregularly cylindrical, and each contains a large blood cavity communicating with the cavities in the two limbs of the filament.

There are several such bridges between the limbs of each filament in a well-grown specimen. The particular filament figured had three interlamellar connections; but other filaments of the same animal showed four. In *Modiola*, on the other hand, the filament limbs are united by a continuous membrane (Fig. 7, *A*, *b*) which extends from the point of flexure for more than half the length of the reflexed limb. Sectioning shows that this membrane is composed of a very loose connective tissue with abundant blood spaces. The question immediately arises which of these types of connection is to be considered primitive. On other grounds than gill structure the view was expressed in a former paper ('98) that *Modiola* is the more primitive form. In that connection the *a priori* argument was advanced that the *Mytilus* type of gill filament might be easily derived from the *Modiola* type, while an independent origin of the interlamellar bridges of *Mytilus* would be more difficult to conceive.

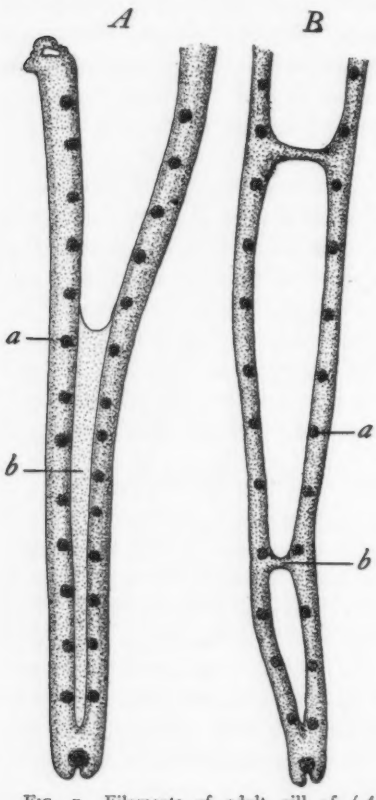

FIG. 7. Filaments of adult gill of (*A*) *Modiola* and (*B*) *Mytilus*. Only a part of *Mytilus* filament represented. *a*, interfilamentary connection (ciliated disk); *b*, interlamellar connection.

The examination of the development of these bridges confirms this view. Fig. 8 shows, in outline, the tips of five consecutive filaments of the gill of *Mytilus*. The filaments are arranged in the order of their occur-

rence in the gill; but the order of developmental stages is not the same. In the latest stage (Fig. 8, *E*) an interlamellar connection is present at a considerable distance from the tip of the filament; in the next younger stages (Figs. 8, *A*; 8, *C*) the connection is found nearer and nearer to the tip of the filament. Finally, in the earliest stage (Fig. 8, *B*), there is no distinct connection; but the distance through which the two limbs of the filament are in union at the tip as compared with the much shorter distance in Figs. 8, *A*; 8, *C*; or 8, *E*, shows a potential interlamellar connection in an undeveloped condition. The comparison with the

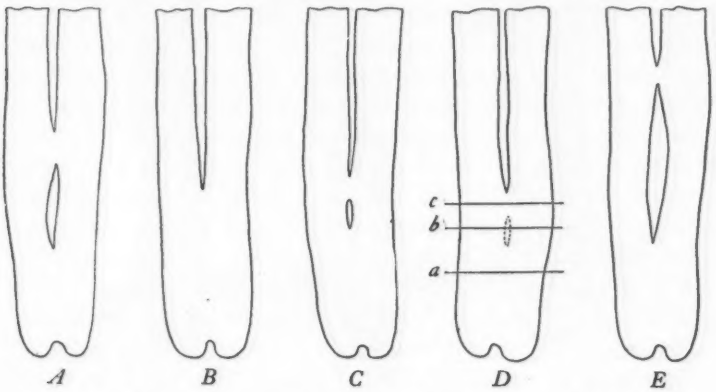

FIG. 8. Tips of five consecutive filaments of inner gill of *Mytilus* of 6 mm. length, showing formation of first interlamellar connection. Filaments represented in order of occurrence in gill; order of developmental stages of interlamellar connection is *B*, *D*, *C*, *A*, *E*. Magnification 110.

continuous connecting membrane of *Modiola* is evident, and it is hardly going too far to call this a "*Modiola* stage" in the development of the filament of *Mytilus*.

Perhaps the most interesting stage in the development of the interlamellar connection is shown in Fig. 8, *D*, which shows clearly the mode of formation of the *Mytilus* type of connection from its *Modiola*-like anlage. The filaments shown in Fig. 8 were first studied and sketched as total preparations, then sectioned. The study of the total preparation indicated that the area bounded by dotted lines in Fig. 8, *D*, was not an opening

like that separating off the interlamellar connection in the other filaments. The appearance was rather that of a thinner spot or constriction preliminary to complete perforation. Study of the sections fully confirmed this interpretation. In Fig. 9 three such sections are represented, their positions being represented by light horizontal lines in Fig. 8, *D*. The section nearest the tip (Fig. 9, *A*) shows a direct connection between the cavities of the two

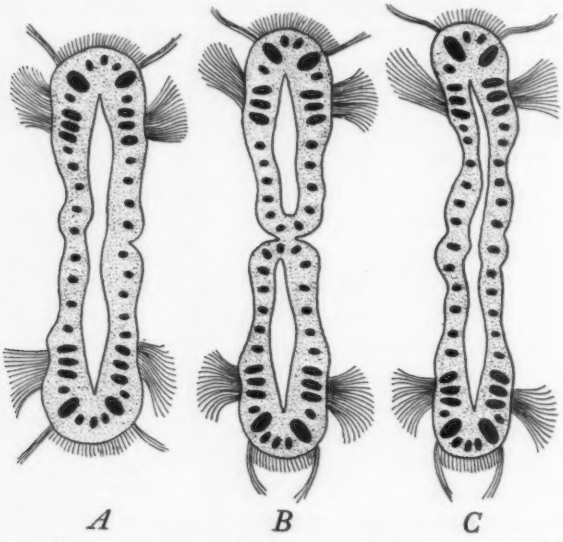

FIG. 9. Transverse sections of filament represented in Fig. 8, *D*. Position of sections shown by horizontal lines in Fig. 8, *D*, marked with corresponding letters. Magnification 540.

filament limbs in the neighborhood of the edge of the gill. Corresponding sections of other filaments show the same arrangement. The section farthest from the tip (Fig. 9, *C*) shows an essentially similar arrangement, which is duplicated by sections through the interlamellar connections of the other filaments. In the intermediate section (Fig. 9, *B*) the gill filament is strongly constricted, and the connection of the cavities of the two limbs is entirely interrupted. The next stage would be a complete perforation in place of this constriction, and the local separation of the filament limbs. Three successive degrees of such separation are shown in Figs. 8, *C*; 8, *A*; and 8, *E*.

Development of Interlamellar Connections in Other Lamellibranchs.

All stages in the development of the interlamellar connections in *Mytilus* have been repeatedly observed; but the investigation has not been extended to other genera. The similarity of the structure of the interlamellar connections in certain other forms, *e. g.*, *Astarte*, suggests similarity of development. But in the majority of the lamellibranchs the structure of these connections resembles *Modiola* rather than *Mytilus*.

General Conclusions.

There is a very striking parallel in *Mytilus* between the formation of the interlamellar connections (p. 71) and the separation of the two limbs of the later gill filaments (p. 68). In each case a flat, plate-like organ becomes locally thinner and is finally perforated. The parallel may be extended, though less fully, to the separation of the upper ends of the reflexed limbs of these later filaments from the gill axis (p. 70). As regards the two latter processes, at least, the parallel has been further extended to embrace several other widely divergent genera (p. 71), and is probably capable of general application. Moreover an essentially similar process may be recognized in the formation of slits in the primitive gill fold, as described by Hatschek ('80) and Sigerfoos ('96) for *Teredo*, and by Ziegler ('85) for *Cyclas*. The general process of perforation or separation in gill development appears to be of very common occurrence among the lamellibranchs.

The opposed process of fusion is equally characteristic. In the *Mytilus* gill this process is reduced to a minimum, but it may be noted in the fusion of the ends of the reflexed filament limbs. Other forms, however, show a high degree of fusion in the development of complicated inter-filamentary connections, represented in *Mytilus* by the simple ciliated disks; and an entirely different type of fusion has been noted in a former paper ('00) as occurring in certain of the complexly folded gills.[1] And, finally,

[1] This paper has been criticised by W. G. Ridewood ("On the Structure of the Gills of the Lamellibranchia," *Phil. Trans. Royal Soc. London*, Ser. 3, Vol. 195, 1903), who holds that the phenomena there described should be interpreted as the result of a splitting of filaments, not a fusion. I see no reason to change my previous view. As regards the present argument, splitting, like fusion, would indicate plasticity of the gill.

in many genera there is a more or less extensive fusion of the reflexed lamella of the outer gill with the mantle and of the inner gill with the body mass, or, posteriorly, with the corresponding lamella of the other ctenidium.

The frequency and prominence of these two opposed processes in development strengthen the conviction earlier expressed ('98) that the lamellibranch gill is an extremely plastic organ and one very liable to adaptive modification. This being the case, it is not an organ of fundamental phylogenetic importance, and has been given an altogether undue prominence in recent classifications of the Lamellibranchiata.

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THE EFFECT OF LOW TEMPERATURES ON HYDRA.

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In his experiments on *Hydra*, Greely, '03, observed that when the temperature is reduced, there occurs, what he termed, a reversal of vital phenomena. The body is quickly reduced to a resting stage, to an undifferentiated mass of protoplasm. He describes the changes as follows: "Whenever a *Hydra* is exposed to a temperature of 4° to 6° C., the tentacles gradually become shorter and thicker, and are finally completely absorbed into the body. As the absorption goes on, the ectoderm and endoderm cells of the tentacles lose their individuality and form an undifferentiated mass of protoplasm which is slowly taken into the body of the *Hydra*. The tentacleless body of the *Hydra* becomes slowly resolved into a dense spherical mass of coagulated protoplasm, in which no distinction between the individual cells can be made out, and remains in this condition as long as it is kept at a low temperature, but quickly forms tentacles and a double layer of cells again when it is returned to the temperature of the room. If *Hydra* in the earlier stages of the process of budding be placed at a temperature of 4° C., not only does the growth of the bud stop instantly but absorption of the bud into the body of the parent commences, and continues until all traces of the bud have disappeared. . . . Six or seven days are required for the complete disappearance of the bud. . . . Lowering the temperature brings about a reversal of vital phenomena and the formation of simple resting stages."

Greely, '01–'02, in an earlier series of experiments traced in protozoa a similar reversal of vital phenomena brought about by reducing the temperature. He found that when the temperature is lowered the protoplasm of unicellular forms coagulates, with accompanying loss of water and the cells pass into resting stages. His experiments on *Hydra* led him to conclude that similar changes may take place in metazoa.

Reversal of vital phenomena due to causes other than reduction of temperature has also been described. Loeb, '00, in campanularian hydroids produced similar effects in the polyps by bringing them in contact with solid bodies. In the same paper he describes like changes brought about by gravity. In *Antennularia* he found that when the branches are placed horizontally the polyps on the lower side are quickly absorbed.

Miss Thacher, '03, working on *Eudendrium*, *Pennaria*, and *Campanularia*, repeated Loeb's experiments, studying at the same time the histological changes. She found that the absorption as described by Loeb is not due to contact with solid bodies, but that it is a true degeneration caused by unfavorable conditions. At all times whether in contact with foreign bodies or not she found that the polyps of these hydroids are absorbed when brought into the laboratory and that the absorption is always preceded by degeneration.

Gast and Godlewski, '03, describe a similar degeneration of the polyps of *Pennaria* when kept in the laboratory.

The series of experiments described in this paper was begun with a view only of determining the histological changes which take place in *Hydra* when the temperature is lowered. Greely in his work considered merely the grosser structural changes. It was soon found that *Hydra* when subjected to low temperatures, often, in fact, usually do not behave as described by Greely. Exposure to a temperature of 2° C. for nine days, that is two degrees lower and three days longer than he found necessary to obtain a complete resting stage, if other conditions such as the composition of the water in which the *Hydra* are kept are unchanged. produces little or no effect on the structure. There may be no indication whatever of a reversal of vital phenomena. Because of this direct contradiction of results, it was thought advisable to repeat Greely's experiments, using as large a number of *Hydra* as possible.

Hydra fusca and *Hydra viridis* were the forms used. *Hydra fusca* is more favorable for experimental work than is *Hydra viridis*, since it is much more resistant to changes in the composition of the water; and also to sudden changes in the temperature. However with proper care either *Hydra* may be employed.

During the experiments the *Hydra* were usually kept in water from the ponds where they had been collected, although they appear to live as well in ordinary tap water. The water was changed frequently since even at low temperatures there is considerable evaporation.

When the *Hydra* were to be studied histologically they were fixed in an extended condition in a hot corrosive-acetic mixture, run up through the graded alcohols, embedded in paraffin and cut in sections, 5μ thick. The sections were stained in hæmatoxylin-eosin.

The series includes about twenty experiments on something like seventy-five *Hydra*. From this number, five typical experiments have been chosen for description. Two of these were on *Hydra* collected in the winter, three on those collected in the summer.

Experiment 1. — February, 1907. One well-expanded brown *Hydra* was placed in an ice box, kept at a temperature of 2° C. The *Hydra* slowly contracted. At the end of nine days it was removed and appeared then as shown in Text-fig. 1, *B*. The body and tentacles had contracted until they were about one third the normal expanded length. The body had decreased somewhat in volume as if shrinkage had taken place. Upon removal from the ice box the temperature of the water around the *Hydra* was quickly raised to that of the room. When the temperature reached 8° C., the *Hydra* began to expand and by the time it had reached 10°, the *Hydra* had stretched to the length shown in Text-fig. 1, *C*. It had just the appearance of a normal expanded *Hydra* except that the tentacles were slightly shorter and somewhat opaque. When stimulated the *Hydra* rapidly contracted to the size shown in Text-fig. 1, *A*. Viewed under the low power of the microscope, while still alive it showed apparently normal structure; two distinct cell layers, nematocysts, etc. Ten minutes after its removal from the ice box the *Hydra* was fixed. Sections of the fixed *Hydra* showed practically normal cell structure, Fig. 6. The *Hydra* used in this experiment was taken from a pond having a temperature of about 10° C.

Experiment 2. — November, 1906. A brown *Hydra* with a small bud was kept at a temperature of 4° to 6° C. for eight days.

(The *Hydra* had been collected in a pond having a temperature of 12° C.) When removed from the ice box both body and tentacles were about one half contracted. The bud was about the same size it was when the experiment was begun. Sections showed body, tentacles and bud all with distinct cell structure, Figs. 1–4. The minute changes in structure shown by these sec-

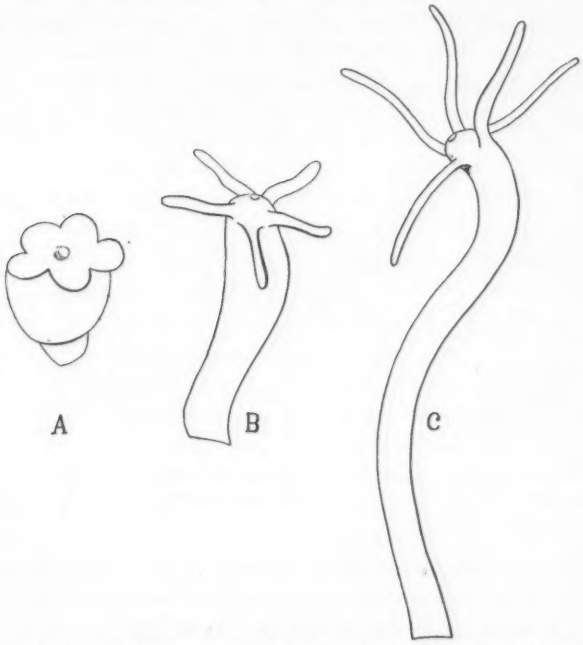

FIG. 1. *Hydra* after an exposure of nine days to a temperature of 2° C.; *B*, when taken from the ice box; *C*, two minutes later, the *Hydra* now at the temperature of the room; *A*, one minute later still; the expanded *Hydra* had been stimulated and rapidly contracted into this small mass.

tions will be described in detail in a separate paragraph farther on.

Experiment 3. — July, 1907. A brown *Hydra*, taken from a pond having a temperature of 30° C. was kept at 4° for six days. It gradually contracted and when removed appeared as drawn in Text-fig. 2, *A*. The body was a spherical mass with tentacles almost completely withdrawn. As the temperature was raised it

began to lengthen but could not stretch out to more than one third the length of the normal expanded *Hydra*. The *Hydra* was fixed and sectioned. The sections show distinct cells but in places, especially in the tips of the tentacles, there are marked cytological changes, changes such as might be brought about by a rapid loss of water.

Experiment 4. — July, 1907. The *Hydra* used in this experiment was collected at the same time as that used in experiment 3. It was a large brown *Hydra* with two buds, one large with long tentacles the other small with no tentacles. It was kept at a temperature of 4° to 6° C. for six days. At the end of the experi-

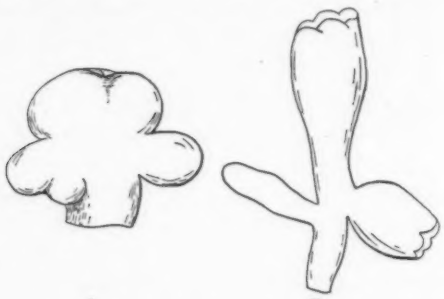

FIG. 2. A budding *Hydra* after an exposure of six days to a temperature of 4°; *A*, when taken from the ice box; *B*, two minutes later when brought to the temperature of the room.

ment it was firmly contracted, Text-fig. 2, *A*. When the temperature was raised it rapidly became active and in a few minutes extended until it appeared as shown in Text-fig. 2, *B*. It seemed incapable of expanding farther. The *Hydra* was fixed and sectioned. It still had clear cell structure, Fig. 5.

Experiment 5. — July, 1907. A *Hydra* taken from a pond at a temperature of 30° C. was kept for seven days at 4°. At the end of the time it was contracted into an oval mass, the tentacles showing only as tiny knobs. When brought to the room temperature it could expand only very slightly, so little, in fact, that some magnification was necessary in order to detect it. When observed under the microscope while still alive no cell layers could be seen. Sections of the *Hydra* after fixation,

in only a few places showed cell boundaries. The body was in the main a mass of protoplasm with degenerating nuclei scattered through it, that is a syncytium. The nuclei were small and pycnotic, showing direct evidence of degeneration.

From the above experiments it will be seen that the changes which take place in *Hydra* when subjected to low temperatures, are somewhat variable. Those collected in summer, when the water in which they have been living is warm react differently from those collected in winter when the water is cold. In *Hydra* from cold ponds (temperature 8° to 12° C.) lowering the temperature to 2° and keeping it there for as long as two weeks has little effect except to cause contraction for the time being. As soon as the temperature is raised, they assume their ordinary expanded form. Usually the tentacles are slightly altered. They become opaque at the tips and cannot expand as far as before exposure to cold. *Hydra* that are budding show no absorption of the bud such as described by Greely. As soon as such *Hydra* are placed at room temperature the buds, as well as the parent body, become actively contractile.

Hydra collected in summer when the pond water is warm show more marked effects when the temperature is reduced. They contract into small masses and when brought, after several days exposure to cold, into water the temperature of the room, do not immediately expand to their normal length. Even in summer *Hydra* I have never observed absorption of the buds except in cases where there was distinct degeneration, due to some other condition than low temperature. Both summer and winter *Hydra*, when the temperature is reduced, lose in volume. This loss is more pronounced in the summer than in the winter *Hydra*.

The cytological changes brought about by low temperatures are interesting. They are in the main such as can be ascribed to loss of water. When more marked changes take place they are always accompanied by distinct evidences of degeneration. The temperature effects are always much more pronounced in *Hydra* collected in summer than those collected in winter. Fig. 6 is drawn from the endoderm of a winter *Hydra* which had been kept at a temperature of 2° C. for nine days. The structure is

almost identically that of a normal *Hydra*, except that the vacuoles in the cytoplasm are not quite so large and the nutrient spheres are not so numerous. The distended condition of the gland cells is worthy of note. This *Hydra* has practically the same structure throughout that one deprived entirely of food for an equal length of time would have. Here, then it is impossible to say whether there are any changes whatever due directly to reduction of temperature. In this *Hydra* there are, at any rate, no indications of Greely's reversal of vital phenomena. Figs. 1–4 are from sections of a winter *Hydra* after being kept eight days at a temperature of 4° to 6° C. Fig. 1 shows the entire thickness of the wall of the tentacle. The protoplasm of both endoderm and ectoderm cells is less vacuolated than in the normal *Hydra* and the nuclei, especially those of the interstitial cells are smaller and more deeply staining. In Fig. 2 the differentiation of the endoderm of the body into endoderm cells and gland cells is apparent. Even in the bud of this *Hydra* the cells are still intact. Fig. 4 shows a foot cell still filled with secretion. The sections of this *Hydra* show no changes that might not be directly due to loss of water.

In a *Hydra* collected in summer and placed at a temperature of 4° to 6° C. for six days the cytological changes are much more pronounced than in the two winter *Hydra* just described (see Fig. 5). Here the cells are much smaller than normal, the protoplasm is free from vacuoles, gland cells cannot be distinguished in the endoderm, and the nuclei of all the cells are very small and deeply staining. Many of the nuclei, especially those of the interstitial cells, look as if the nuclear sap had been almost entirely extracted leaving only the much condensed chromatin within. In a few places in this *Hydra*, most apparent at the tip of the tentacles, the cell boundaries are indistinct. Where such is the case the nuclei always are beginning to degenerate.

In *Hydra* like the one described in experiment 5, where, after exposure to cold, the body practically loses power of movement even after the temperature is raised, the cell structure is often entirely obliterated. The nuclei are in such cases always pycnotic and both nuclei and cytoplasm show every evidence of degeneration. Since it is seldom that *Hydra* are found which behave in

this manner when the temperature is lowered, it is probable that the loss of cell boundaries is due to some other condition than change of temperature. An entirely similar effect may be produced by keeping the *Hydra* in water that is not frequently renewed. It is possible that the reversal of vital phenomena described by Greely may have been merely a degeneration brought about by some such unfavorable condition. That he was able to get such *Hydra* to return to normal after bringing them to the room temperature for several days is no indication that they had been only in a resting condition. If after the temperature was raised the adverse conditions were at the same time removed, then any intact cells which may have escaped degeneration, might quickly regenerate the entire body. The ability of *Hydra* to regenerate from a few cells is well known.

Greely's statement that *Hydra* when kept at low temperature are resolved into undifferentiated protoplasm is misleading. It is impossible to tell whether he meant merely that the cell boundaries are destroyed, the nuclei remaining intact; or whether the nuclei too, are broken down so that the body is made up of a simple protoplasmic mass entirely devoid of differentiation. The former is probably what he meant. In such event it is possible that after all cell boundaries are destroyed regeneration may take place, but in this series of experiments no evidence of this has been seen. It is most likely that in all his *Hydra* that passed from his so-called resting stage to a normal condition, there had been only a partial destruction of cells, and that the few remaining cells regenerated the body.

Though Greely's results were not corroborated by these experiments yet his statement that reduction of temperature does bring about a loss of water is substantiated. All the effects due to lowering the temperature I think can be ascribed to this cause.

In concluding, it may be repeated that reduction of temperature for the length of time mentioned by Greely does not cause *Hydra* to be resolved into undifferentiated protoplasm. When this does take place it is due to unfavorable conditions and is a degeneration effect and not a temperature effect.

This work was done in the Zoölogical Laboratory of the University of Missouri under the direction of Professor Lefevre, to whom I am indebted for many valuable suggestions.

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Explanation of Plate IV.

Abbreviations. *En*, endoderm cell; *ec*, ectoderm cell; *l*, supporting lamella; *ic*, interstitial cell; *nut*, nutrient sphere; *nem*, nematocyst; *s gl*, secretion granule; *gl*, gland cell of the endoderm; *p*, pigment; *cnid*, cnidoblast cell.

Fig. 1. Cross-section of the tentacle of a *Hydra* exposed eight days to a temperature of 4° to 6° C. *En*, endoderm; *nut*, nutrient sphere; *l*, supporting lamella; *ic*, interstitial cell; *ec*, ectoderm cell; *nem*, nematocyst.

Fig. 2. Endoderm from the body of the same *Hydra* as Fig. 1. *En*, endoderm cell; *gl*, gland cell; *p*, pigment; *nut*, nutrient sphere.

Fig. 3. Cross-section of the body of the bud of the same *Hydra* as Fig. 1. *En*, endoderm; *l*, supporting lamella; *ec*, ectoderm.

Fig. 4. Gland cell from the foot of the *Hydra* described in Fig. 1. *S g*, secretion granules.

Fig. 5. Cross-section of the body wall of a *Hydra* exposed for six days to a temperature of 4° to 6° C. This *Hydra* had been collected in summer from a warm pond. Notice the few vacuoles in the cytoplasm. *P*, pigment; *en*, endoderm; *l*, supporting lamella; *cnid*, cnidoblast cell; *nem*, nematocyst; *i c*, interstitial cells.

Fig. 6. Endoderm cells from the body wall of a *Hydra* which had been exposed to a temperature of 2° C. for nine days. The structure is almost identically that of a normal *Hydra*. *Nut*, nutrient sphere; *gl*, gland cell; *p*, pigment.

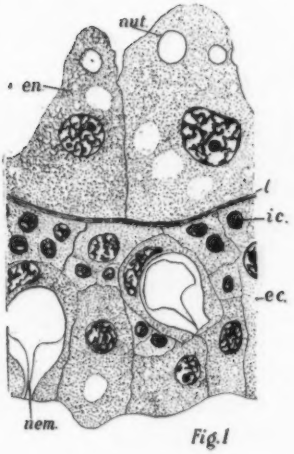

Fig. 1

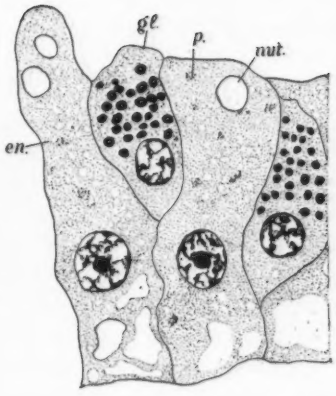

Fig. 2

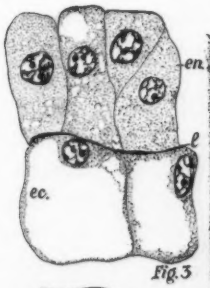

Fig. 3

Fig. 4

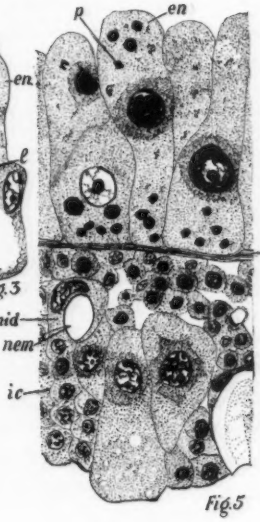

Fig. 5

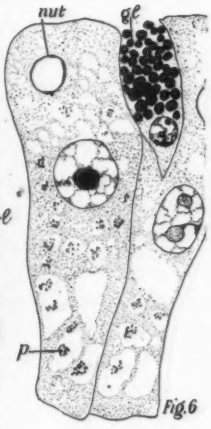

Fig. 6

AMITOSIS IN THE MALPIGHIAN TUBULES OF THE WALKING-STICK (DIAPHEROMERA FEMORATA).

WM. S. MARSHALL.

Schindler[1] in his paper on the Malpighian tubules of insects describes both direct cell division and budding of the nucleus. In amitotic division he notes a regular form in which the nucleus is first cut in two and then followed by the cell (in *Sarcophaga carnaria*), and also, in *Lophyrus pini*, a peculiar method in which the division passes from one side of the nucleus towards the other.

While working on the anatomy of the walking-stick it was often noticed, in studying sections through different parts of the body, that mitotic figures were quite abundant. In looking over serial sections cut through the head, thorax, or abdomen, mitosis was often observed in cells in the fat, tracheæ, epithelial cells of the ovarian tubules, etc., but nothing of the kind was ever seen in the Malpighian tubules. Later, all the slides in which any Malpighian tubules could be found, were reëxamined in an endeavor to find dividing nuclei. Other slides were then prepared, both sections and entire tubules, etc., and, while no mitotic figures could be found, some nuclei dividing amitotically were seen.

Attention has already been called[2] to the two kinds of Malpighian tubules in *Diapheromera femorata;* these differ in their size and in their position within the body of the insect. In both kinds of tubules the cells are binucleate.

The greater part of the material used was taken from mature or nearly full grown insects. Tubules were also prepared from a number of walking-sticks about one third full grown. Besides these two stages a number of the insects were hatched out in the laboratory and the tubules taken from some which were not more than four to six days old. Embryos in which the tubules had developed were also sectioned. This gave four different stages;

[1] E. Schindler, "Beiträge zur Kenntniss der Malpigi'schen Gefässe der Insecten," *Zeit. wiss. Zool.*, Vol. XXX., 1878.

[2] W. S. Marshall and H. H. Severin, "Ueber die Anatomie der Gespenstheuschrecke, *Diapheromera femorata*," *Arch. Biontol.*, Vol. I., 1906.

embryos, specimens but a few days old, insects one third full grown and mature insects.

In a longitudinal section through an embryo two or three weeks before it was ready to emerge from the egg, the Malpighian tubules were easily seen and the condition of the nuclei noted. The tubules were narrow and short but, proportional to the length of the body of the insect, were, I judge, about the same as in mature specimens. In these tubules a few mitotic figures were seen (Fig. 1) but no instance of a direct nuclear division could be found. It was impossible to find any cell boundaries and nothing could, at this stage, be determined as to the binucleate character of the cells. In the tubules of mature insects the nuclei often lie in pairs, the two of each pair being nearer to each other than to the others; each pair being within a single cell. In the embryos studied the nuclei were very much crowded together and no such arrangement was possible; this crowding together of the nuclei made the relationship in size of nucleus to cell very different from what was found in the mature insect where the cell was, in proportion to the size of its nuclei, very much greater than in the embryo.

In the tubules of very young walking-sticks, four to six days old, no dividing nuclei were seen. Both in structure and in relative size proportional to the tubule, or rather that part one might imagine to be the cell, the nuclei were here similar to those found in the embryo. Here and there two nuclei were seen with their opposing surfaces very close to or touching each other — if cell boundaries had been visible these two nuclei would, no doubt, have been within the same cell. In these young insects it was noticed that other organs did not show nearly so many mitotic figures as were found in maturer specimens.

In insects about one third grown the cells of the tubules were, in proportion to the nuclei, much larger than in the younger insects. In the old specimens, none of which had completed egg-laying and some had not yet begun, no mitotic figures were ever seen although, as already mentioned, nuclei dividing indirectly were fairly abundant in the other organs of the body. Thousands of cells were examined from the older insects and no trace of mitosis was ever seen in the Malpighian tubules.

There is no visible difference in the nuclear division in the large and in the small tubules, and, while nuclei from both kinds are figured, a description of one will hold good for both. The size of the nuclei of the larger tubules is much greater than of the smaller ones. Each nucleus contains a number of chromatin granules, held in a reticulum, and several nucleoles which stain with the safranin of Flemming's triple stain and with the fuchsin of an acid-fuchsin-methyl green solution. The nucleoles are of different sizes and are scattered irregularly within the nucleus: in division some pass to each of the daughter nuclei. The size of the nuclei in each tubule varies considerably as does their position, some lying with their long axis across and some with it parallel or oblique to the tubule. Most of the cells are arranged with their long axis parallel to the length of the tubule but they do not all occupy this position. The nuclei generally divided parallel with the tubule although some oblique ones were seen.

At the commencement of division the nucleus first assumes an irregularly oval outline very similar to the resting nuclei except a somewhat greater elongation (Fig. 5). The nucleus then narrows transversely (Fig. 2) until it becomes apparent that it is dividing amitotically (Figs. 3 and 4).[1] An examination of nuclei at this stage shows that the nucleoli are about to become fairly evenly distributed between the two daughter nuclei; all those not near the center of the nucleus continue in or near their original position while those near the center are pushed, as this part grows narrower, into one or the other of the daughter nuclei. As the central part becomes more of a connecting strand the two main portions change their outline becoming more circular and losing the elongated appearance they had in the earlier stage. Just after the completion of division the daughter nuclei project in a point towards each other showing where the connecting strand has severed (Fig. 6).

While most of the cells are binucleate it was found that a number of cells contained but a single nucleus. All cases of amitosis seen were found occurring in the nucleus of the uninucleate cells. In the binucleate cells amitosis was never seen.

[1] J. B. Carnoy, "La Cytodiérèse chez les Arthropodes." *La Cellule*, Vol. I., 1885.

It would seem that in the Malpighian tubules of the embryo some of the cells were left with but a single nucleus and that later, by amitosis, these cells became binucleate.

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Explanation of Plate V.

All figures drawn with a camera-lucida.

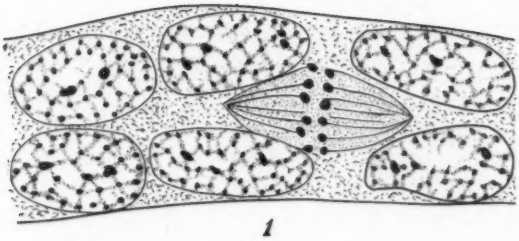
Fig. 1. Small piece of a Malpighian tubule from an embryo walking-stick. × 2,200.

Fig. 2. A nucleus showing early stage of amitotic division; from a large tubule. × 750.

Figs. 3 and 4. Nuclei in a somewhat later stage; both from small tubules. × 1,200.

Fig. 5. Elongation of nucleus preparatory to division; from large tubule. × 1,200.

Fig. 6. Nucleus of large tubule after completed division. × 1,200.



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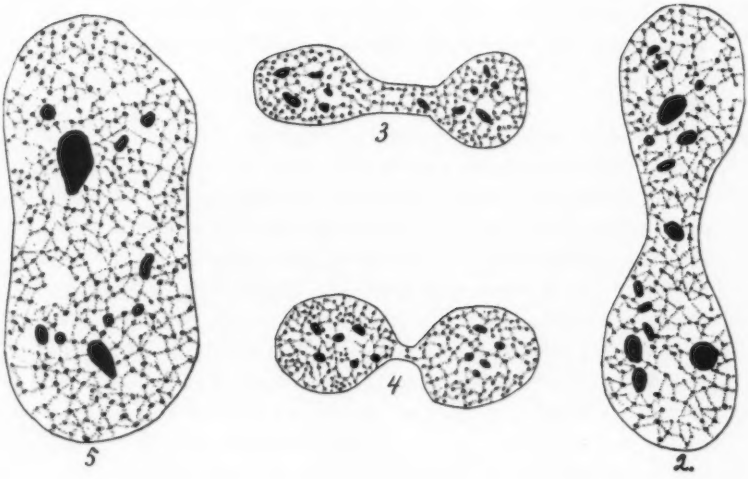

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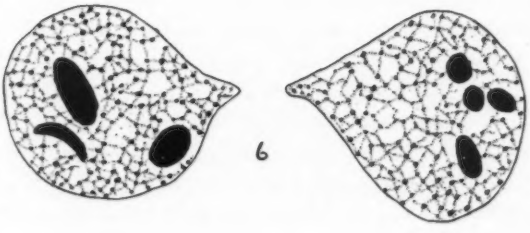


6

NOTES ON A FEW CŒLENTERATES OF WOODS HOLL.[1]

CHAS. W. HARGITT.

The following notes concerning a few Hydrozoa and other Cœlenterates, some new and others more or less rare, of the Woods Holl Region, and made chiefly during the summer of 1906, are published in the belief that portions of them at least are of more or less interest, particularly in view of the biological survey of the region now under way under the direction of the Bureau of Fisheries. It seems also worth while noting certain biological aspects of these organisms which are but indifferently recognized.

Hydroids.

Eudendrium.—Among the prolific hydroid fauna of the region, few if any genera of Gymnoblastea are more abundantly represented both in species and individuals than *Eudendrium*. And among the species of *Eudendrium* perhaps none is so conspicuous in size or so abundant as *E. ramosum*. About docks, piers, in tide pools, in open waters and water of a depth of ten to twenty fathoms or more, the species is more or less abundant everywhere. Apparently the first record of the species in American waters was by McCrady in his now classic monograph ("The Gymnophthalmata of Charleston Harbor," p. 166), and by him identified with the *E. ramosum* of Europe.

It has long been a query in the mind of the present writer why, in the rather extended and painstaking work of Professor Agassiz, there seems to have been no acquaintance with this species. In his elaborate monographs on these forms he only mentions this species as a native of European waters. And in the later "Catalog of North American Acalephæ" of A. Agassiz (p. 160), it is only mentioned as having been taken by Clark in Charleston Harbor. And even as late as Verrill's "Invertebate Animals of Vineyard Sound" (1871, pp. 408, 734), its occurrence is merely mentioned, with no account of its characteristics or

[1] Contributions from the Zoölogical Laboratory, Syracuse University.

distribution. Can it be possible that this species is a recent comer into this region, or has it become more prolific and abundant of recent years, or was its earlier presence simply overlooked by naturalists? So far as I know these queries must remain such, at least for the present. In this connection I desire to note the variable character of the species when found in deeper waters. As known in shallower habitats it is usually stout, with dense stems much fascicled and profusely branching; while from depths of fifteen or more fathoms it is often more slender, stems weak, colony less massive and complex, and with gonads of variable colors and characters, the whole resembling somewhat *E. dispar*.

EUDENDRIUM DISPAR. — This species most resembles the preceding in its general size and aspects of any of the series. While not to be ranked as especially rare, it is yet far from common. This may be due, in part at least, to the fact that its habitat is usually the deeper waters, ten to thirty fathoms, hence only available by means of the dredge. But this does not fully explain its comparative rarity, for the writer has collected by all known means for fifteen years throughout the region, and this species has not been taken on an average once per year during this period. It may therefore be ranked at present as rather rare.

In this note it is desired to call attention to the fact of the considerable variation in morphological characters shown by the species as taken from varying depths and other environmental differences of habitat. Agassiz in the original description of the species (*Cont. Nat. Hist.*, Vol. IV., p. 286), states that the branches and pedicels are extensively annulated. Later students have generally followed Agassiz in this respect. As a rule such is true in a majority of cases, but it should be pointed out that specimens are found in which there is considerable variation, the annulation resembling much more nearly that of *E. ramosum*. Again other specimens will be found in which the annulation extends to the entire stem, as well as to the branches and pedicels. The most distinctive difference, and most constant, is to be found in the character and position of the gonophores. These I have found to be very constant, and agree quite closely with the figures of Agassiz.

In distribution the species seems to be more common in Buz-

zards Bay though I have taken it several times in the deeper waters in the region of Gay Head.

EUDENDRIUM ALBUM.— This species was first described by Nutting in 1898. In a "Synopsis of the Hydroids" (*Am. Nat.*, Vol. XXXV., p. 310), I expressed some doubt as to the distinctness of Nutting's species. During the present year I have taken two colonies of this little hydroid, which seemed to differ in important points from *E. capillare* and *E. tenue*, the species which I had considered probably identical. In comparing these several species, having obtained specimens of *E. capillare* from Naples, there seems no longer any good reasons for doubting their distinctness.

EUDENDRIUM CARNEUM.— This species, first described by Clarke, was taken at three different points during the summer, namely, from piles of the docks of the Vineyard Haven Yacht Club; from fucus off Naushon; and later dredged off Gay Head. It is not a common species at Woods Holl. In general characters it might easily be mistaken for young colonies of *E. ramosum*, but may be distinguished usually in the sexually mature stage by its smaller size, rarely exceeding two inches in height and by the flesh red color.

HYDRACTINIA.— Two points of some interest will be noted concerning the local species of *Hydractinia*, first, the rather interesting range of habitat which characterizes it; and second, some facts bearing on the question of the affinities of the species.

As is well known the more familiar habitat of the species is the shell inhabited by hermit crabs. So general is this conception on the part of zoölogists that it is often given as *the distinctive* habitat, and that because of this peculiarity it is cited as one of the more common illustrations of *symbiosis*, and not infrequently pains are taken to show just wherein these creatures sustain essential relations of mutual helpfulness and interdependence. But every careful student of hydroids knows very well that *Hydractinia* has a range of habitat which would be clearly incompatible with the foregoing conception of necessary symbiosis. Agassiz long ago pointed out in his original description of the species, *H. polyclina*, that it was to be found covering rocks in

tide-pools, sometimes to the extent of several square feet. The same fact has also been pointed out by McCrady, Leidy, and others. During the current season I have records of the following modes of life: The general occurrence on shells occupied by hermit crabs; the maxillipeds of the lobster; the chela of the common crab, *Cancer irroratus;* stems of common rock-weed; dredged in Vineyard Sound on bit of waterlogged oak timber; finally in immense masses from piles of docks at Vineyard Haven, and still later from the carapace and legs of *Limulus.* The occurrence on the appendages of the crab and lobster are sufficiently similar to that on the shell of the hermit crab to make it devoid of special significance. But the occurrence and distribution in the other cases are certainly not compatible with any necessary commensal relations. On the other hand they go to confirm the suggestion made above, and also long ago suggested by Agassiz, that there is probably no essential advantage to this hydroid in its habitat on the shell of the crab. Certainly in the enormous colonies of the hydroid on these stationary substrata we cannot perceive any adverse conditions so far as the animals are concerned, for not only were the vegetative conditions among the most remarkable known, as shown by the enormous colonies, but they were apparently in the height of sexual development, both male and female colonies being abundant, and ladened with gonads.

The second feature to be noted, as intimated above, is the question as to the specific distinctness of local species. As is well known, Agassiz regarded it as specifically distinct from the European *H. echinata*, and designated the species as *H. polyclina.* In my Synopsis (*op. cit.*), I followed Allman in his rather emphatic doubt on this point, and designated the species as *H. echinata.* In connection with the unusual numbers taken during the present season, and their range of habit, I took occasion to go carefully over the subject once more, reviewing as carefully as possible all the evidence available, and find myself unable to distinguish any good grounds for regarding these two species, so-called, as sufficiently different to warrant the distinction. And when one recalls the fact that two systematists of the acknowledged renown of McCrady and Leidy both regard our species as

identical with the European, it should call for very convincing evidence to decide to the contrary. I do not overlook the fact that Professor Nutting, who has seen the European species, believes that Agassiz's early decision was correct, but the only evidence he cites in its favor is the "larger hydranths and less number of tentacles," of the English species, both of which characters are exceedingly variable ones, and hardly admissible alone from which to predicate specific distinction.

In some of the colonies collected during the summer I thought for a time that some such differences as Nutting indicated were present, particularly on those taken from piles. But upon a comparison of other colonies they were entirely lacking; and still other comparisons showed such apparently indistinguishable intergradations of characters that I was compelled to regard them as too variable to warrant the establishment of an independent species. I must therefore return to my earlier impression with increasing conviction, namely, that our species of *Hydractinia* is to be regarded as identical with that of European waters, and is therefore *H. echinata* Fleming, and not *H. polyclina* Agassiz.

CORDYLOPHORA. — This hydroid is known to have a very wide range of distribution, but so far as I recall at this time only a single species is known, namely, *C. lacustris* Allman. It was first found at Woods Holl by Professor Morrill in 1899, in Nobska pond, who kindly turned it over to me for identification.

Since then I have taken it in several similar ponds in the region and near Falmouth, and in fresh or brackish ponds on Marthas Vineyard. Indeed the hydroid seems to be quite generally distributed throughout the region. The more common habitat is on fragments of rock, or on bits of submerged sticks, eel grass, etc. Occasionally it forms large and rather complex colonies, the hydrorhiza forming an intricate network from which branching stems arise to a height of about an inch or slightly less. The reproductive season seems to be chiefly in spring or early summer, and sparingly in July. Colonies have been found later, September or October, but with no signs of gonophores. As I have pointed out in an earlier paper (*Zoöl. Bull.*, Vol. I., p. 205), it lives well under the artificial conditions of aquaria, but only

in its vegetative phases, no sexual organs appearing. Furthermore, if these be present when brought to the aquarium they soon show signs of degeneration, and later disappear.

CORYNITIS. — This genus was instituted by McCrady for a hydroid and medusa described by him from Charleston Harbor (*Proc. Elliott Soc. Nat. Hist.*, Vol. I., p. 131), and named in honor of Professor Agassiz *Corynitis agassizii*. Notwithstanding the fairly full description, especially of the medusa, the latter illustrated by good figures, a most remarkable confusion has crept into the literature in reference to the supposed affinities of the species. From material which has come into my possession within recent years, and from facts gathered therefrom it now seems possible to clear up the matter once for all.

About the time that McCrady described the above named species Agassiz also described a new hydroid which he designated as *Halocharis spiralis* (*Cont. Nat. Hist.*, Vol. IV., p. 239). For some unaccountable reason he subsequently came to regard this species as identical with McCrady's *Corynitis*, and on page 340 gives priority to the latter name, ranking *Halocharis* as a synonym. That this was not simply a clerical error is evident in that on page 344 he recognizes McCrady's *Zanclea gemmosa* as quite distinct from *Halocharis*, and this error is perpetuated by A. Agassiz in his "Catalog of N. Am. Acalephæ," p. 183. These errors have continued throughout the literature up to the present time, though as will be shown, it has later been determined that the medusa which McCrady described as *Zanclea*, or rather *Gemmaria gemmosa*, is liberated from a hydroid resembling Agassiz's *Halocharis spiralis*. That Murbach, who first observed the liberation of this medusa, was correct in identifying it with McCrady's *Gemmaria gemmosa*, I have abundantly satisfied myself at various times since. But he is clearly in error in attempting to identify it with McCrady's *Corynitis*, due no doubt, to the earlier error of Agassiz as already pointed out. Murbach is also in error in attempting to distinguish a generic difference between Agassiz's *Halocharis* and the *Gemmaria* of European writers, as I have elsewhere pointed out (*Mitt. Zool. Sta. Neapel*, Vol. XVI., pp. 574–577, "Medusæ of Woods Holl," 1904, p. 42).

In the summer of 1904 the writer described an apparently new species of hydroid from Long Island Sound, namely, *Syncoryne linvillei* (BIOL. BULL., Vol. VII., p. 351). Not having access at the time to McCrady's monograph, and with the current confusion above referred to still more or less dominant, the details of McCrady's description of *Corynitis* were wholly overlooked. A more recent and critical examination of this has clearly convinced me that the hydroid in question is quite identical in its generic relations with *Corynitis*, and should be so ranked hereafter. Whether it is specifically the same as *C. agassizii* must remain more or less uncertain, at least till it may be possible to have specimens of free medusæ for comparison, these having been lacking in the material from which my description was drawn.

FIG. 1.

That there may be no doubt whatsoever as to the facts concerned, or of the confusion alluded to, it seems worth while to present several of McCrady's figures with others, and to include also some summary of his descriptions.

Concerning the *hydroid*, his description is rather inadequate and indefinite. "The larva is a coryne with a short, thick polyp and few tentacula. The medusa-buds borne in the usual position, and the peculiar character of the tentaculiferous bell-margin is conspicuous at an early age." Of the habitat of the hydroid he says: "The coryne which bears this medusa is rather rare, as is also the medusa. It is found growing on sponges a little above dead low water mark. It has been found during the summer months and whether or not it exists during the winter

(as in all probability it does), has not been ascertained. A young bitentaculate, but free medusa, has been found as early as the fifth of June. A fully developed specimen has occurred in the end of July, while as late as the twelfth of September, buds were still produced from the coryne, Figs. 6, 7 and 8 having been drawn at this date. This leads me to say that I have not seen the actual separation of a bud from the hydroid, and its assumption of the form of Fig. 5. My confidence that they are one and

FIG. 2.

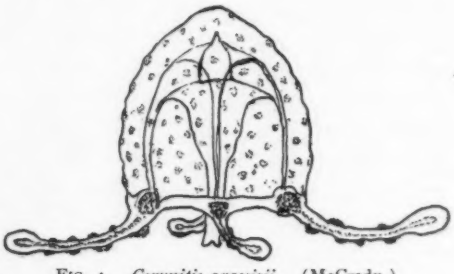


FIG. 4. *Corynitis agassizii.* (McCrady.)

FIG. 3. *Corynitis.* (McGrady.)

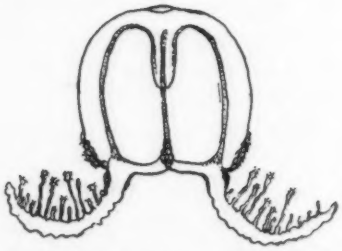


FIG. 5. *Gemmaria gemmosa.* (After McCrady.)

the same is due to the very marked and almost unmistakable peculiarities of the medusa, which are fairly exhibited in the buds while attached to their hydra."

As will be seen, there is little here from which one might attempt to identify the hydroid. Aside from the fact that it is designated as a corynid, and that it has a short thick hydranth with

few tentacles, the medusa-buds in the "usual position," no morphological features are given. The habitat and association with the sponge are interesting facts, but without taxonomic significance.

It is unnecessary to repeat here the characters by which *Syncoryne linvillei* is distinguished. A glance at the figure (1) of a portion of a colony, with the reference already cited, will suffice to afford ample opportunity for comparison to those concerned. I may add, however, as was intimated in the original description, that while having generic characters in many points conformable with those of *Syncoryne*, still there are points of considerable difference. And with McCrady's figures and description before one it is at once apparent that my species belongs to *Corynitis* and not to *Syncoryne*, as already intimated.

A comparison of the several figures of *Corynitis* and *Gemmaria* will make more evident the points under consideration. For example, a comparison of Figs. 2 and 3 which represent corresponding stages in the medusæ of *Syncoryne linvillei* and *Corynitis agassizii* will strongly suggest their close resemblances and probable generic identity, as already indicated.

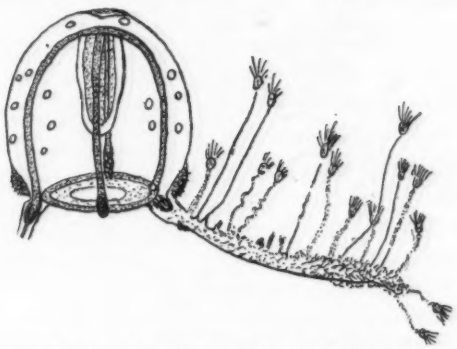


FIG. 6. *Corynitis agassizii.* (After Murbach.)

Futhermore, a comparison of Fig. 4, representing the free medusa of *Corynitis agassizii*, taken directly from McCrady's drawing, with Figs. 5, 6 and 7, representing medusæ of *Gemmaria*, will also show one at a glance the unmistakable distinctness of the medusæ portrayed. Fig. 5, copied from McCrady, represents

his well-known genus *Gemmaria*. Fig. 6, copied from Murbach's figure of *Corynitis*, confused by him with the very different genus of this name, gives a good picture of the medusa of *Gemmaria gemmosa*, to be discussed in the following section. Likewise, Fig. 7, from the writer's description of *Gemmaria implexa*, also shows beyond doubt the distinctive gemmarian features.

With these figures, and facts cited bearing upon the problems concerned, there can hardly be reasonable doubt as to the conclusions to be drawn. *Syncoryne linvillei* must be identified with the genus *Corynitis;* and the *Corynitis* of later literature must be identified with the genus *Gemmaria* of McCrady.

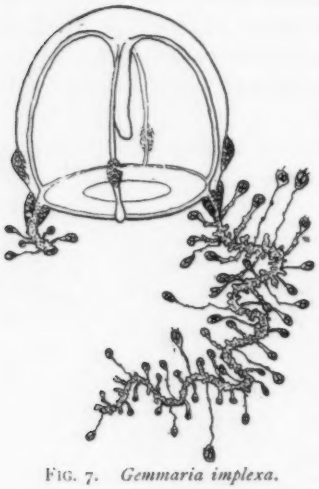


FIG. 7. *Gemmaria implexa.* (Naples.)

It is therefore to be hoped that the long-standing confusion here referred to may be once for all removed by recognition of the facts as given. And while it is too much to anticipate that similar confusion along kindred lines may be avoided entirely, the lessons of past experience should count for something in rendering their occurrence less frequent, or of such persistence.

GEMMARIA. — Attention has been directed to the confusion of McCrady's *Gemmaria* with his very different genus *Corynitis*. A similar confusion has also been more or less current as to the relations of *Gemmaria* and *Zanclea*. The latter was instituted by Gegenbaur for a medusa found at Messina, and recognized by McCrady as having certain points of similarity to his doubtful *Gemmaria*, which he believed however, to be quite generically distinct from *Zanclea*.

Having taken a medusa at Woods Holl during several years which is now well known as identical with McCrady's *Gemmaria*, and having kept these medusæ at various times and for considerable periods in the laboratory, I am convinced that they are beyond

doubt generically different from *Zanclea*. Briefly diagnosed, *Zanclea* was described by Gegenbaur as having four short oral lobes, four radial canals and the same number of marginal tentacles, the latter with numerous secondary appendages (Anhängen).

In at least two aspects there are important differences in *Gemmaria*, viz., the mouth is not marked by any distinguishable lobes or lips; and second, there are only two marginal tentacles. These latter do not increase in number with age, so far as one may judge by having them long under observation. This is likewise true of *Gemmaria implexa*, taken by the writer at Naples, and described briefly in a paper in the Naples Mittheilungen (Bd. XVI., p. 574).

It would seem therefore that the genus *Gemmaria* of McCrady must be recognized as founded on thoroughly good characters, and that is it quite distinct from *Zanclea* of Gegenbaur. Hence we must also accept McCrady's *G. gemmosa* as a distinct species, and this name must entirely supplant that of *Corynitis agassizii*, as pointed out in the preceding section.

Colonies of the hydroid are quite frequently taken at Woods Holl, and from a considerable variety of habitats, *e. g.*, on shells of *Mytilis*, *Pecten*, serpulid tubes, pebbles dredged from various depths, pieces of waterlogged wood likewise dredged from similar depths, and from floating *Sargassum*. In one particular, however, there has been an interesting uniformity in every case which has come to my notice, namely, the colonies are invariably associated with encrusting polyzoa, usually *Schizoporella* or *Membranipora*, and almost always with those colonies characterized by pinkish or orange colored pigment, affording a background which resembles very remarkably the color of the hydroid. The hydrorhiza forms an intricate network over the polyzoön, but so far as I have been able to perceive there is no special evidence of mutualism between the organisms.

The following note concerning the peculiar nettling organs of the medusæ may not be amiss. The extension of the stalk bearing the nettling organ is apparently brought about by a sort of rotary, or oscillatory motion of the capsule, involving a spinning-like operation by which the thread becomes extremely delicate almost to the point of invisibility. After attaining its full extension the capsule continues its motion for a variable time,

when the stem finally contracts in a way to suggest that of *Vorticella*, though without the coiling of the stem as in the latter organism. I am inclined to regard the organ as probably possessed of a tactile function.

ECTOPLEURA. — While dredging off Gay Head on board the "Fish Hawk," July 15, 1907, I was fortunate in discovering on the carapace of a small specimen of the common spider crab, *Libinia*, among other hydroids not uncommon on this creature, including a species of *Campanularia* and *Halecium articulosum*, a small tubularian-like hydroid having a very short stem, large hydranth, the latter being crowded with racemose clusters of medusa-buds, some almost ready to be liberated. In appearance the hydranth, in its size and general aspects, was much like *Tubularia crocea*, though rather larger, and the oral tentacles fewer in number. A closer inspection under a lens, and later under the low power of the microscope, soon made it evident

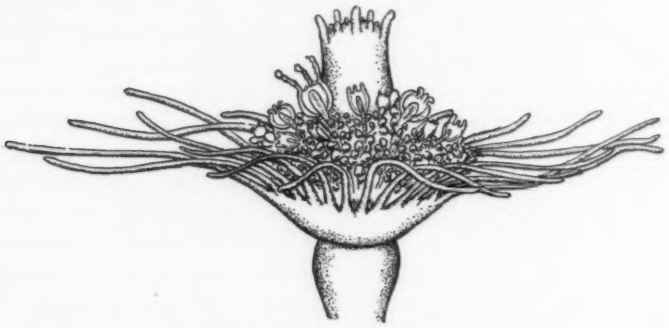


FIG. 8. *Ectopleura prolifica.*

that the specimen did not belong to *Tubularia*, and the liberation soon after coming to the laboratory of several medusæ made this doubly certain. An examination of the medusa soon showed that we had under examination a species of *Ectopleura*. Since no description of the hydroid of this genus has been recorded from this region it seemed worth while to have a careful sketch made of it, which is shown in Fig. 8.

The following are the chief points of diagnostic importance. Stem of hydroid very short, hardly exceeding 5 or 6 mm., and

devoid of definite perisarc. (This may be due in part to the habitat, on the crab, these animals being given to decorating themselves with various living organisms, such as hydroids, polyzoa, algæ, etc., and if this hydroid were there by such process its very short stem devoid of perisarc may be due to its recent transplantation.) The hydranth is rather large, with two whorls of tentacles, the basal series about twenty-four in number, long, and filamentous, much as in *Tubularia;* oral tentacles few and short, about ten or twelve, apparently in two series, one *very* short, merely bud-like. Hypostome of hydranth rather cylindrical, entire hydranth low vasiform, and with definite constriction below the body. Medusa-buds borne on body of hydranth in series of racemose clusters, as shown in Fig. 9. Growth of medusæ apparently rapid, the older forming the terminal portion of the cluster Color of hydranth pinkish red, tentacles paler.

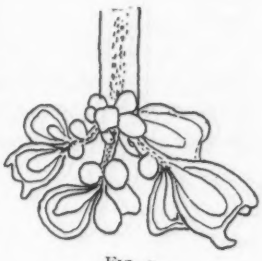


FIG. 9.

MEDUSA. — Bell transparent, subspherical or when older oblately spheroidal; diameter when first liberated about .5 to .6 mm., and becoming but little larger after several days in the laboratory, Walls of bell rather delicate, though not flabby; velum very delicate, with tendency to evert during contraction. Radial canals four, rather open showing free movement of circulating fluid. Tentacles four, rather short, and terminating in knob-like masses of nematocysts, body of tentacles with nematocysts in scattered clusters of four to six in number usually, though some specimens seemed all but devoid of them. The entire exumbrella of newly-born medusæ is more or less dotted with clusters of nematocysts. A characteristic feature of the medusa is the presence of eight rows of nematocysts arching over the exumbrella from the basal bulb of each tentacle, a row on either side. Basal bulbs rather prominent, and with scattered granules of pigment throughout their substance. Manubrium relatively large or thick and not extending at any time to the level of the velum, mouth devoid of lobes or lips of any sort.

Color. — Bell very transparent, or with only the slightest tint of color by reflected light ; tentacular bulbs and base of manubrium brownish red due to the presence of scattered pigment granules in the entoderm ; tip of manubrium slightly bluish by reflected light. While the colors may be easily distinguished they are incomparably inferior to those of *E. ochracea*, a very nearly related species.

Dr. A. G. Mayer has informed me that the hydroid of *E. ochracea* has been taken by him at Newport and that it has much in common with the hydroid here described. The characters of the medusa are, however, very different from that of the former.

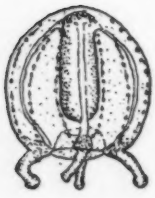


FIG. 10. Aspect of newly born medusa.

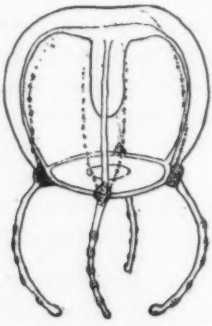


FIG. 11. Aspect of fully developed medusa.

Having taken those medusæ by hundreds for many years one could hardly confuse them with any other known species. It had seemed possible that this might be identical with McCrady's *Sarsia turricula* but a careful comparison of the original figures and description makes it perfectly certain that the species are wholly different ; indeed I am inclined to believe that *S. turricula* is evidently of a different genus, as McCrady has indicated, and that Agassiz was in error in placing it under his newly established genus, *Ectopleura*. The only species with which the present one is at all comparable is the *Tubularia dumortierii* of Van Beneden, but here again there are points of difference, especially in the size and features of the medusa. It seems therefore rather probable that we have here a new species, or in any case a variety

entitled to identity, hence I am disposed to suggest for it the name *E. prolifica*, which may be specific or varietal, as the results of later comparison of material may warrant.

AGLAOPHENIA. — During the summer I collected from masses of *Sargassum* which was blown into the harbor from Vineyard Sound, a species which seems in all essentials identical with Fewkes' *A. minuta*. The hydroids were entirely devoid of gonangia, as was the case with the species as originally described by Fewkes, whose account was extremely brief, and without figures — "Found growing in great abundance on an Alga over the fronds of which the *hydrorhiza* extends." (*Bull. Mus. Comp. Zoöl.*, Vol. VIII., p. 132.)

Nutting has since described and figured the gonangia, using material collected by Fewkes, and indicated as types, though as already mentioned, the original description made no mention of the gonosome.

In a recent paper on "Bermuda Hydroids" Mr. E. D. Congdon has a brief note on the species, found there on *Sargassum*, but as in my specimens, devoid of gonangia.

So far as I am aware, the present is the first record of the species at Woods Holl, and this mention of it seems therefore important.

OBELIA. — The present note refers only to a single species, and of that only to the medusa, which up to the present time, seems to have been entirely unknown, or at any rate undescribed.

The material was collected by Mr. Geo. M. Gray at Woods Holl in April, 1906, and in the aquarium numerous medusæ were liberated. The hydroid was clearly *O. flabellata* Hincks.

The following synonymy is given by Haeckel, "Das Syst. d. Medusen," p. 177:

Thaumantias plana Sars., 1835.
Campanularia flabellata Hincks, Ann. Mag. Nat. Hist., 3d, Vol. XVIII., p. 297.
Obelia flabellata Hincks, Brit. Hydr. Zoöphytes, p. 157.
Eucope plana Agassiz, Cont. Nat. Hist. U. S., Vol. IV., p. 351.
Obelia plana Haeckel, vide supra.

There would seem therefore to be more or less uncertainty as to the exact affinities of the species, as will appear in what follows. As to Agassiz *E. plana* there is no description. Hincks' description relates only to the trophosome and is thus far clear and sufficient. But of the medusa he gives no account, and indeed states that it is unknown, or doubtful.

Haeckel's description relates only to the medusa, but is apparently entirely inapplicable to our species. *E. g.*, his species has forty-eight tentacles at birth, and at maturity from 100–120. Diameter of new-born medusa 1 mm., and at maturity 6 mm. Gonads on distal half of radial canals.

The following characters are diagnostic of our species:

In general features quite comparable with other well-known

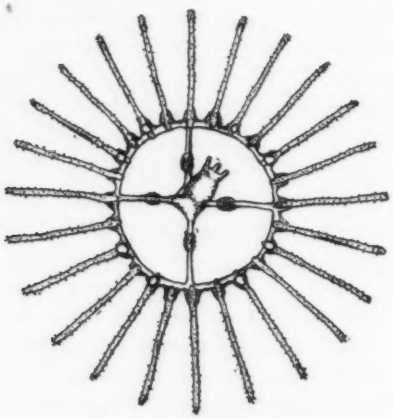


FIG. 12. *Obelia flabellata.*

medusæ of *Obelia*. In common with others the creature has the habit of everting the bell at will, and again recovering its shape Radial canals 4, gonads ovoid in shape and borne about midway between stomach and margin of bell, well-developed at birth. Tentacles 24 in number at birth, number in adult not known. Manubrium rather large, mouth four-lobed. Diameter of medusa at birth .4 to .5 mm. Size in adult not known.

Hence as was suggested above, it seems quite evident that Haeckel's species is not identical with that of Hincks, as shown

by the foregoing comparisons. Fig. 12 gives a general view of the medusa as seen from the subumbrellar surface.

AGLANTHA CONICA. — This species was collected by the writer in August, 1902, and described shortly after (BIOL. BULL., Vol. VI., p. 21). It has not since been taken till the present summer, or spring, when, April 25–30, it appeared in small numbers in the tow at Woods Holl. These specimens agreed in all essentials with those of 1902, except in a slightly larger range of size. In the former specimens the average height of bell was given 5–6 mm. In the specimens of this year, only about a dozen in number, the average was about 8 mm. in height. The marginal tentacles were quite as in the earlier description, and there were no apparent morphological differences between the smallest specimen taken, of 5 mm., and the largest, measuring 12 mm. These facts seem to confirm the previous somewhat provisional designation of the species as new, and warrant the belief that *A. conica* is a well-defined species, distinct from the only other indigenous species, *A. digitalis*. Its occurrence at such widely different seasonal periods as August and April is a point of some biological interest. The gonads were about equally developed in the specimens of each season, and this may also suggest that it has no sharp limits as to seasonal relations.

As a supplementary note it may be added that again specimens have been taken at Crab ledge in late July, 1907, in considerable numbers by towing, as in my original collections, and agreeing in every respect with the original type specimens.

EUTIMA. — Two species of *Eutima* have been recognized by earlier students of Hydromedusæ, namely, *E. mira* McCrady, and *E. limpida* A. Agassiz. In notes by the present writer (*Am. Nat.*, Vol. XXXVI., p. 554), reference was made to *E. limpida* as "Fairly common at Woods Holl, but sexually immature." Upon later and more critical comparison of these medusæ I found it extremely difficult to distinguish more than a single species, and so designated it as *E. mira* McCr. (cf. *Bull. U. S. Bureau of Fisheries*, 1904, pp. 45, 46), though listing *E. limpida*, on the authority of Agassiz, but with the suggestion that it was probably at most but a regional variety of *E. mira*. Still later observations have served to confirm this impression.

LOVENELLA GRANDIS. — This species was first described by Nutting from material dredged in Newport Harbor in 1901. So far as I am aware it has not since been taken. Specimens of the hydroid have since been obtained by the writer at Woods Holl. The colonies were somewhat fragmentary, but still justified Nutting's designation of it as "a beautiful species," and one could wish it were more abundant.

SERTULARIA VERSLUYSI. — For the first time this interesting hydroid has been found at Woods Holl during the present summer. Its habitat on *Sargassum* renders it not unlikely that this is not the first time the species has drifted into these waters, but failed of recognition. Congdon has also taken it on drifting *Sargassum* at Bermuda. A feature of the specimens taken by me, and not mentioned by other observers, is the presence of stolon-like outgrowths from the tips of branches and stems. These are more or less common on my specimens, and it seems somewhat strange that they should not have been observed before.

Rhegmatodes. — This beautiful medusa (*R. tenuis* A. Agassiz), occurring at very irregular periods, and in a very erratic manner, made its appearance during the first week of September, 1907, in considerable numbers and in its characteristic manner. During the last week in August a very few small and immature specimens were taken in the tow, and suddenly large numbers of full-grown medusæ appeared in Buzzards Bay adjacent to Woods Holl, hundreds of which were obtained with dip nets. On the following day not a single specimen could be found. The presence of wind and some rain may have been influential in some measure in the sudden disappearance, but perhaps not entirely. This is the first time the species has been seen in numbers since the summer of 1900.

CAMPANULARIA. — In assorting some specimens in the collections of the Fisheries laboratory a single valve of *Modiolus* was found on which several specimens of a species of *Campanularia* were found which at first inspection seemed rather strange. A closer examination showed them to belong to the species *C. verticillata* (Linn.).

While Nutting lists this species in his "Hydroids of the Woods Hole Region," it is apparently on the authority of Verrill, who records the species as having been taken in the region of Block Island, and in Fisher's Island Sound. The specimens hereunder mentioned were obtained by Vinal N. Edwards off Sankety Light, Nantuckett, from a depth of 25 fathoms. This would seem therefore to be the first definite record of the species from the immediate region, if indeed this may be so designated.

A few points as to structural features seem worthy of note. One interesting fact not hitherto mentioned in its morphology, though well known in the fascicled stems of the Plumularidæ, is the intercommunications of the several stem elements by means of strands of cœnosarc, adjacent tubes showing very clearly such connecting strands. This may be seen in the enlarged drawing, Fig. 17. It is most evident near the apical region, and probably occurs during rapid growth. Another point not mentioned, though probably known, is the variable number of stems in a given fascicle. In young specimens the tubes were as few as five, while in others they were more numerous. Fig. 16 shows the general aspects of a colony.

In size my specimens varied from 20 to 30 mm. in height, the stems ending abruptly at the distal end, as shown in the figures.

No gonangia were present on any of the specimens. This fact with that of the small size of the specimens, would seem to indicate their immaturity.

LAFŒA. — On the same shell from which the previous specimens were taken I also found a species of *Lafœa* of whose exact relations I am in some doubt. There were features which at first inclined me to regard it as *L. gracillima*. Further comparison showed still other features allying it with *L. pocillum*. Unfortunately, the specimens had been allowed to become dried up before they were recognized, hence the uncertainty in their identification.

A single gonosome was found encasing in part a stem of *Tubularia* on which the colony was growing, and in part the stoloniferous portion of the colony. Its features were very much like that figured for *L. dumosa*.

PASYTHEA. — Among hydroids obtained from the gulf-weed were found extensive colonies of what seems clearly to be a species of *Pasythea*, a genus hitherto unrecorded anywhere within our northeastern Atlantic coast region. Indeed only a single species of this genus is recorded from American waters (Nutting, "American Hydroids," Part II., p. 75), namely *P. quadridentata* Lamx., specimens of which he reports from the British West Indies. From a careful comparison of Nutting's figures and description, as well as those of Lamarck, Lendenfeld, and others, my specimens seem to have so many points of difference as to suggest the probability of their being undescribed. Hence it seems important that a rather full description be undertaken, which is given below.

FIG. 13.

Trophosome: Colony consisting usually of a simple unbranched stem, varying in height from 4 to 9 mm., or averaging about 6 or 7 mm., and rising from a creeping hydrorhiza which forms an intricate network over the stems and leaves of the alga. The stem is divided into a series of internodes by oblique nodal articulations, as shown in Fig. 13. Each of these internodal segments bears from one to five pairs of opposite, and closely appressed, hydrothecæ, the mouths of which are quite divergent as shown in the figures, especially in internodes having several pairs, the terminal pair of which in such cases are much less so, owing no doubt to the absence of pressure from above. The number of internodes varies greatly on different stems, as is shown in the accompanying table. The average, estimated from a series taken more or less at random, seems to be about five, though this is probably somewhat dependent upon age or conditions of growth. Furthermore, the size of internodes is likewise variable, even more than their number. This is largely a matter of the number of hydrothecæ upon a given internode. A glance at the table, and a comparison of the figures, will make this quite obvious without extended verbal description. Usually

the lower, or basal internode contains the fewer pairs of hydrothecæ, one or two, or rarely three pairs, and the more distal nodes a larger number. But this again is subject to great variations. It might appear as if these nodulated stems were so many expressions of rhythms of growth, in which there would naturally be a gradual increase in the size of successive internodes up to the optimum, followed by a corresponding decrease in size as the organism passed this optimum of activity. And many stems show just this feature in a very striking way. On the other hand there are so many exceptionally different examples as to throw serious doubt upon the suggestion.

Margins of hydrothecæ are usually characterized by two or three, rarely four, tooth-like processes, but occasionally specimens are almost smooth, or entire. There seem to be two or three opercular flaps closing the mouths, though this feature is difficult of certain demonstration.

Gonosome, entirely unknown.

TABLE SHOWING NUMBER OF INTERNODES, AND PAIRS OF HYDROTHECÆ ON EACH, FOR TEN COLONIES TAKEN AT RANDOM.

No. of pairs of hydrothecæ on each internode.								Number of Internodes.
	I.	II.	III.	IV.	V.	VI.	VII.	
	2	3	3					
	1	4	3	4				
	3	4	2	5				
	3	2	3	with terminal stolon				
	2	3	3	4	4	3		
	3	3	3	3	4	4	3	
	2	3	3	3	5			
	2	3	5	4	2	4		
	3	4	3	4	4	3	3	
	2	3	5	4	3	with two terminal stolons		

Among the more distinctive differential characters of the species as compared with *P. quadridentata* are:

1. The apparently larger number of internodes to each stem, seven being not uncommon, and in one case eight were present. In *P. quadridentata* the number as given by Nutting is two, or occasionaly three or four.

2. The larger number of pairs of hydrothecæ to each internode. This feature will be quite apparent from the table. In the other species the number is only two or three.

3. The rather stouter and shorter nodal portion of the stem. Nutting's figures show these much more slender and long.

4. The tendency in certain stems to form divergent branches from the sides of the internodes, as shown in Fig. 15.

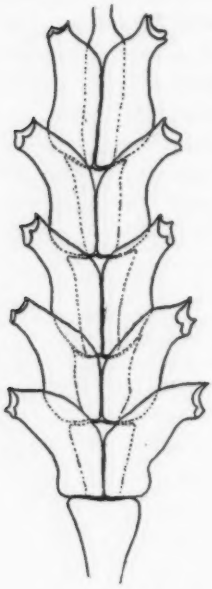


FIG. 14.

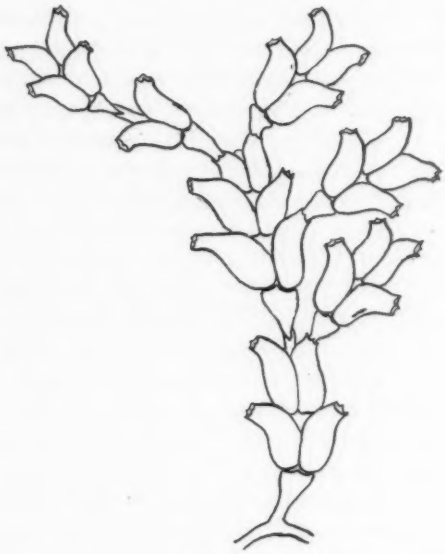


FIG. 15.

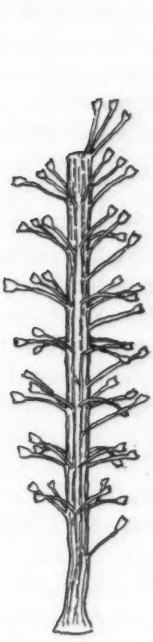
5. The very common and rather distinctive occurrence of terminal and lateral stolons on the stems, from which at irregular intervals secondary stems arise.

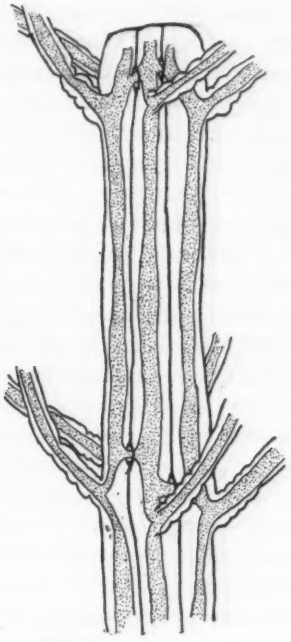
It is much to be regretted that no gonangia were present on any of the specimens, as this would have afforded almost certain proof as to the affinities of the species. It may be found that when specimens are obtained from other localities and in larger numbers, though the numbers in the present case were large, the present species will have only a varietal importance. Still, I am

strongly inclined to believe that it is quite distinct and probably new, and hence will propose for it the name *Pasythea nodosa*, the name being suggestive of a highly distinctive feature of the hydroid, namely the nodose aspect of the stem.

Fig. 14, single internode enlarged. Fig. 15, colony with branches.

Distribution and Habitat.—Known only on floating *Sargassum.*





Campanularia verticillata.

FIG. 16. FIG. 17.

ANEMONIA SARGASSENSIS. New species.

During the summer a very interesting species of actinian was found by the writer in a mass of *Sargassum* brought in by Mr. Edwards from the sound, and in working over some material collected during the preceding summer other specimens were found to have been taken by Mr. Edwards and preserved in

formalin. An examination of the literature at hand failed to give any clue as to their specific, or even generic relations. Subsequent investigation pointed to more or less close affinities of the genus *Anemonia*, of Risso. But there seems little doubt of the fact that the species has not hitherto been described. The following summary of characters will suffice for its general features, and a more detailed account of its anatomical features will shortly be published in another communication.

Column short and irregular in shape, about half as high as broad. Column obscurely fluted, and with pedal disk well developed and adapted to clasping the sea weed, to which it adhered with tenacity. Oral disk characterized by a series of white or cream-colored radiating lines extending from the mouth to the bases of tentacles or even slightly outward on the bases of the larger ones.

Tentacles cylindrical in shape, but slightly contractile, though more or less prehensile at the distal portions; the number varying with size, from 25 to 30 in smaller specimens, to about 50 in the larger, and in length from 5 to 15 mm., tapering to acutish ends, the inner series nearly twice the diameter of disk. The tentacles also are definitely adhesive, sticking to anything with which they come in contact. In several cases bifurcated or forked tentacles were found, adding to the more or less irregularity and asymmetry of these organs.

There are no acontia, nor marginal tubercles. Color a more or less diffused brownish or chestnut, variegated by the whitish markings on tentacles and disk, giving to the creature a close resemblance to the olive brownish color of the *Sargassum*, and rendering its presence difficult of detection. It shares this feature in common with perhaps the large proportion of the fauna of the *Sargassum* forest.

Supplementary Note.

Since the foregoing notes were written and about to be sent to press I have received Hartlaub's admirable paper "Craspedote Medusen" (Part XII. of Nordisches Plankton), in which he discusses certain problems relating to *Gemmaria* and *Zanclea*. With most of Hartlaub's views my own will be seen to be in substantial agreement. Concerning his contention as to the

identity of the genera *Gemmaria* and *Zanclea* of McCrady and Gegenbaur I should have to dissent, at least until such time as more convincing evidence than is at present adduced shall be submitted. Reasons for this will be seen in what has been said in the sections dealing with these subjects. It seems desirable, however, to offer a few additional suggestions bearing upon the matter.

Admitting the doubt expressed by McCrady as to the distinctness of his proposed genus, which was only what might have been expected under the circumstances, the fact must not be overlooked that subsequent students of medusæ have generally accepted without hesitation the validity of McCrady's genus. A. Agassiz who was quite familiar with the medusæ of *Gemmaria* has described a second species under it, namely, *G. cladophora;* and in a comparison of *Gemmaria* and *Zanclea* says: "The form of the bell, of the digestive cavity and of the tentacles are totally different in the two genera" ("Cat. N. Am. Acalephæ," p. 185).

Haeckel also has always recognized the distinctness of the two genera, and has himself described a new species under *Gemmaria*, namely, *G. sagittata.* He says: "Up to the present time the genus *Zanclea* has been represented only by a Mediterranean species, *Z. costata* from Messina. L. Agassiz added to this two other species, *Z. ambigua* and *Z. gemmosa.* Of these however, the first is to be placed under *Pteronema*, the latter under *Gemmaria.*" ("Syst. der Medusen," p. 102.)

In Hartlaub's revised definition of *Zanclea* he has naturally enlarged that of Gegenbaur in order to include under it medusæ hitherto described under *Gemmaria.* But in so doing he fails to submit any grounds of sufficient warrant for a measure thus radical. Let it not be overlooked that thus far the ontogeny of Gegenbaur's medusa is wholly unknown. And furthermore, that even the medusa itself has been rarely seen, or certainly identified by later naturalists.

I do not overlook the circumstance that Browne has described specimens of *Gemmaria implexa* having four tentacles, which he seems to regard as older specimens of those which when first liberated have but two tentacles. This however is merely an *inference*, for he has not traced these four-tentacled specimens to

their hydroid, and until this is done the matter must remain an open question. The same objection must be urged concerning a similar inference on the part of Hartlaub, in which he would identify Gegenbaur's *Z. costata* with that described by the writer at Naples and referred (doubtfully) to *Gemmaria implexa*. Therefore the attempt to identify and unite *Gemmaria* with *Zanclea* must be regarded as unwarranted and inadmissible, and hence premature.